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BOOK REVIEW

# Darrell Duffie: Dark markets, asset pricing and information transmission in over-the-counter markets

## Princeton University Press, 2011, approx. 35 USD

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In response to the financial crisis of 2007 to 2009, a large number of financial assets, such as derivatives, collateralized debt obligations, and repurchase agreements, which are traded in over-the-counter markets (OTC) are receiving increasing attention. A key feature of OTC market is its decentralized nature, that is, agents negotiate prices with each other, often pairwise, and thereby may be uninformed of prices currently traded elsewhere in the OTC market. In this opaque market, the bargaining game between market participants can be complex due to different levels of private information and various sets of outside opportunities. As a result, agents have difficulty assessing the prices and risks of OTC instruments and thus the investment behavior in OTC markets has intensified the financial crises. Some regulatory steps have been taken by the U.S. and European governments to increase competition and transparency in the OTC markets (e.g., Dodd–Frank Act in the United States).

In this context, Darrell Duffie is a key contributor to the promising new research area of OTC markets, which is relatively undeveloped compared with literature on central market mechanisms. *Dark Market* provides an introduction to the topic and gives an overview of different asset pricing models in OTC markets characterized by symmetric and asymmetric information. Duffie seeks to understand and model the behavior of participants in decentralized markets and study the effects on asset prices and returns. He also provides a valuable framework for the analysis of how information is transmitted and how asset prices behave over time. He explains key concepts and modeling techniques for search and random matching in economies with numerous agents. The book is divided into a more theory-oriented main part and an appendix that provides further methodological support for the more advanced

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reader. This comprehensive and rigorous book will be very useful to all those interested in broadening their understanding of the mechanisms behind OTC markets and who want to keep current with state-of-the art research in this area.

The first part of the book provides an introduction to OTC markets and lays out their advantages and disadvantages compared to exchange-based trading. In a concise manner, Duffie highlights key research and political issues regarding OTC markets and puts the discussion in the current context of enhanced regulation of financial markets. The author also discusses which products might be especially prone to be traded on an unregulated market due to their nonstandardized nature (e.g., complex contractual features). A brief review of recent theoretical and empirical papers identifies key drivers of asset prices in OTC markets and the influence of search frictions on price behavior, a discussion that is extended in the next chapter. Because of the introductory nature of the first part and its practical relevance, this chapter may be of interest for a more general audience interested in OTC markets.

The second chapter gives an example of an OTC market, namely, the Federal Funds Lending Market in the United States and is based on the paper by Ashcraft and Duffie (2007) entitled "*Systematic Illiquidity in the Federal Funds Market*." It is shown how intraday allocation and pricing of overnight loans of federal funds are reflected in the OTC interbank market. Before explaining the data composition and the model setup, the author provides an introduction and overview of the federal fund market and its special characteristics, information that is needed to understand the following empirical work. The empirical analysis is based on transactions-level data of the top 100 commercial banks by transaction volume. The chapter concludes with a discussion of the effects on federal fund trading behavior and lending activity and highlights influential factors in asset prices and price behavior over time.

In the third chapter, a modeling technique for search and random matching in large economies is introduced with the aim of familiarizing the reader with the baseline methodology that will be employed in the more complex models in Chaps. 4 and 5. The exact law of large numbers for random matching is used to determine the cross-sectional distribution of types of matches across the population. The models presented include a discrete and a continuous time framework for the search and matching behavior of participants in the OTC market. This framework assumes that the agents are randomly matched, and that the probabilities of matching assignments and of exogenous-type changes for each agent depend only on that agent's current type and on the cross-sectional distribution of types in the population. Based on the exact law of large numbers for the random matching, Duffie derives the optimal choice of search intensity for each type, as well as determines the equilibrium search intensities. This chapter concludes with an overview of the theory of the exact law of large numbers from the beginning to current applications in the economics area. Additional sources are suggested for reader interested in diving deeper into the topic.

Chapter 4 introduces a pricing model for a situation in which symmetric information between a buyer and a seller is assumed. (The case of asymmetric information is discussed in further detail in Chap. 5.) In this chapter, the implications of search delays, which frequently happen in OTC markets, on return distributions, investment strategies, and the dispersion of information among participants is analyzed from a

theoretical perspective. Search delays in OTC markets may arise due to arranging financing, negotiating and executing trades, legal restrictions, and so on. In the first paragraph of this chapter a simple model with risk-neutral investors is introduced and the effects on equilibrium search intensities, as well as returns and asset prices, are mathematically and verbally explained in further detail. The chapter continues with an investigation into how search frictions affect prices and returns in a situation where investors receive idiosyncratic liquidity shocks. In addition, aggregated liquidity shocks that affect many agents are discussed and their effect on prices, as well as price and search behavior, is presented. The author shows possible variants and extensions of the basic asset pricing model by, for example, allowing for risk aversion, including dividends, and so forth. The chapter also has two nice numerical examples illustrating the functioning of the asset pricing model with individual and aggregated liquidity shocks.

As the real-world OTC bargaining game can be complex due to different levels of private information and various sets of outside opportunities, Chap. 5 focuses specifically on information transmission in a decentralized market. Complex contractual features can be analyzed in detail only by a narrow range of specialized investors and hence this chapter derives an asset pricing model with asymmetric information among the investors. A simple model of the percolation of information through bids and offers of the participating agents is presented and the dynamics of the cross-sectional distribution of information is solved by employing the exact random matching technique. The remainder of the chapter shows extensions of the basic model by including new private information over time and the information release among groups of more than two participants. To better understand the framework, the author provides examples of different market settings in which the model might be applied, namely, wallet games and double auctions. As a service to the reader, Duffie also explains his idea by means of a numerical example.

In summary, the different topics presented in the book are well chosen and the book covers a great deal of current research in the area as well as provides suggestions for further reading. Most chapters have introduction and conclusion sections as well as some numerical examples, which make it easy for the reader to navigate through the different chapters and the appendix. Although the theoretical models presented are more complex to comprehend, the author finds suitable ways of explaining the derivation of the model and the interpretation of its results. Mathematical notations and variable descriptions are consistent throughout the book and make it easy to switch between the different chapters. In addition, if a different notation is used in the book compared to the related paper, the author shows the reader how to transfer the information. In my point, another of the book's big advantage is that the author introduces several different models but at the same time also shows how to incorporate differing assumptions (e.g., in Chap. 4, the asset pricing model is presented with both risk-neutral and risk-averse investors). A major help, especially for first-time readers of the topic, is the numerical illustrations, which can be found throughout the book (e.g., the numerical example in Sect. 4.4). The book provides various links between theory and existing empirical literature and highlights how the presented models have been empirically tested (e.g., p. 53, paper by Graveline and McBrady 2011).

The book is written in a concise and compact matter, there are some minor points which would enhance the value of the given content. Personally, I noted the absence

of some references to current resources, such as information on relevant homepages, downloadable material, additional readings, or "go-to" tables, all of which could be valuable resources for finance professionals and academics. Also, there are some minor typographical mistakes (e.g., p. 27 "the cross-sectional distribution"), which should be corrected in the following editions.

In conclusion, *Dark Markets* is a sound introduction to asset pricing in OTC markets and helps the reader understand the theoretical mechanisms behind it. The book provides an overview of current research with a focus on OTC pricing models. Hence it is directed to a more advanced audience, including graduate students and other academics as well as finance professionals familiar with the topic. In my opinion, the book is more a collection of papers with an additional introductory section than a standard textbook. In addition, the content is more advanced and requires graduate-level knowledge in financial markets and statistics. Hence, I would recommend *Dark Markets* especially to academics as well as to readers who are already familiar with the topic. Duffie is arguably one of the leading scholars in the area (previous books include *How Big Banks Fail and What to Do about It* and *Dynamic Asset Pricing Theory* (both Princeton)) and hence the book might very well become a standard in the academic world.